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ADDITIONS TO THE TAXONOMY OF THE LIMNORIIDAE (CRUSTACEA: ISOPODA)

L.J. Cookson

CSIRO, Forestry and Forest Products,
Private Bag 10, Clayton South MDC, Vic. 3169, Australia

Abstract

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The crustacean marine wood borers *Paralimnoria andrewsi* (Calman) and *Limnoriasaseboensis* Menzies are described from Australia for the first time. New characters are listed that will aid in the separation of *L. saseboensis*, *L. indica* Becker and Kampf, *L. simulata* Menzies and *L. foveolata* Menzies. *L. indica* and *L. simulata* are considered to be separate species. *Limnoria carptora* sp. nov. is described from algal holdfasts growing at Heard Island in the subantarctic. Additional distribution and habitat records are provided for *L. agrostisa* Cookson, *L. convexa* Cookson, *L. loricata* Cookson, *L. platycauda* Menzies, *L. quadripunctata* Holthuis, *L. rugossisima* Menzies, *L. unicornis* Menzies, and *Lynseia annae* Cookson and Poore.

Introduction

This paper adds to an earlier study (Cookson, 1991) on the taxonomy of the Limnoriidae, an isopod crustacean family of wood-, algal- and seagrass-boring species. Since that publication the Lynseiidae, a supposedly related family, has been dismantled and its species of *Lynseia* transferred to Limnoriidae (Cookson and Poore, 1994), so that with *Limnoria* and *Paralimnoria* there are now three genera in the family. Extensive ecological research in Western Australia has shown that the seagrass-boring species of *Lynseia* and *Limnoria agrostisa* Cookson can heavily colonize seagrass meadows, with possibly important implications for the health of those ecosystems (Brearley and Walker, 1993).

The present contribution re-examines the species *Limnoria indica, L. saseboensis, L. simulata* and *L. foveolata* in an effort to clarify distinguishing features. All four are very similar in appearance, and indeed, Müller (1988) synonymised *L. indica* and *L. simulata*. Also, a new species is described from the subantarctic, and the distribution or habitat records for a further nine species extended (Table 1).

Material for this study was obtained from the Museum of Victoria, Melbourne (NMV); Australian Museum, Sydney (AM); United States National Museum of Natural History, Washington D.C. (USNM); Zoologisk Museum, Copenhagen (ZMUC); Canterbury Museum, Christchurch (CM); and the Bundesanstalt für Materialforschung und -Prüfung (BAM).

Limnoria agrostisa Cookson

Limnoria agrostisa Cookson, 1991: 166–167, 169, fig 10. — Cookson, 1990: 6, 15. — Brearley and Walker, 1993: 415–428, fig 1a.

Material examined. SA, Port Pirie (33°12′S, 138°00′E), 4.1 m, subtidal on *Posidonia* and *Amphibolis* spp: core sample 795-A4/5, T.J. Ward, Aug 1979, AM P38958 (male, 3.75 mm), core sample 801-A4/8, T.J. Ward, Mar 1980, AM P38986 (female, 2.9 mm).

WA, Bramble Point, Princess Royal Harbour (35°03′S, 117°53′E), on *Posidonia sinuosa*, airlifted sample epifauna, 0.1 m^2, Hutchings, Wells and Walker, 20 Jan 1988 (stn P. sinuosa 10), AM P39019 (ovig. female 4.0 mm). Green Island, Rottnest, 1–2 m, from *Amphibolis griffithii*, D.I. Walker, 7 Feb 1989, NMV J37418 (female, with 1 slide, 3.0 mm), NMV J37420 (4 females, 1 male, 2 juv), 6 Feb 1989, NMV J37419 (male, 1.7 mm). Seven Mile Beach, near Dongara, G. Edgar, 1985–1986, NMV J37421 (male, with 1 slide, 2.0 mm).

Previous distribution records. South Australia and southern Western Australia.

Remarks. L. agrostisa was originally described on the basis of just two specimens. In this additional material, one large male from Port Pirie (AM P38958) has a pair of relatively large anterior puncta on the pleotelson, similar in comparative size to that found on *L. unicornis* males, but not recurved. The male sometimes has percopod 7 poorly developed (NMV J37420, J37421).

While *L. agrostisa* has been collected from *Posidonia*, its preferred substrate is *Amphibolis griffithii* (Brearley and Walker, 1993).

Table 1. New distribution records or substrates for the Limnoriidae.

Species	Existing distribution record	Location *new record	Substrate *new record	Museum material
Paralimnoria andrewsi (Calman)	Christmas Islands. Samoa. Hawaii. Japan. Florida. Caribbean. Philippines. Puerto Rico. Ghana. Papua New Guinea. Cocos Islands.	Broome*, Australia	Jarrah heartwood*	NMV J17259
Lynseia annae Cookson & Poore	Geraldton to Dunsborough, Western Australia. Ceduna, South Australia.	Corner Inlet, Victoria*	*Posidonia australis*	NMV J41054
Limnoria convexa Cookson	The Snares, New Zealand	Campbell Island*, New Zealand	*Durvillaea* holdfasts	NMV J37422 NMV J37423 CM 5.37
Limnoria indica Becker & Kampf	Northern Queensland, Australia. Papua New Guinea. Admiralty Islands. Mandapam Camp, Andaman Islands, India. Hong Kong. Manila, Philippines. Koniya, Japan. Penang, Malaysia. Belize. Tobago.	Gladstone*, Queensland (southern limit). Madras*, India	Pine Wood test panels	AM P35418 NMV J37426
Limnoria loricata Cookson	The Snares, New Zealand	Campbell Island*, New Zealand		NMV J37424 NMV J37425
Limnoria platycauda Menzies	West Indies. Puerto Rico. Belize. Cuba. Andaman Islands. Aldabra Atoll. Koniya, Japan. Satta Hip, Thailand. Admiralty Islands. Queensland, Australia. Karwar, India (NMV J37436, see Karande *et al.*, 1993).	Bombay*, India	Himalayan fir	NMV J37435
Limnoria quadripunctata Holthuis	Widespread cool temperate distribution, including New Zealand.	Cook Strait, New Zealand (see Chilton, 1916).	Gutta-percha cable	CM
Limnoria rugosissima Menzies	NSW, SA, Victoria, Tasmania, Australia. The Snares, New Zealand.	Ninepin Point*, Bicheno*, Tasmania. Gabo Island*, Victoria.	*Macrocystis* holdfasts* *Ecklonia* holdfasts	NMV J37434 NMV J37433 NMV J37417 NMV J37416
Limnoria unicornis Menzies	Caroline Islands. Andaman Islands. Palau. Huahine Island. San Salvador. Belize. Papua New Guinea. Northern Australia.	Port Douglas, Queensland.	Dead mangrove branch lying on mud amongst mangroves*	NMV J37454

Limnoria carptora sp. nov.

Figures 1, 2

Material examined. Holotype: Heard Island, Atlas Cove (53°00'S, 74°00'E), lower eulittoral, *Durvillaea antarctica* holdfasts, G. Edgar, 21 Feb 1988 (stn HI C1 6), NMV J17255 (male, 4.4 mm, 1.2 mm wide pleotelson, with 1 slide).

Paratypes: Type locality, NMV J17256 (female, 4.9 mm, with 1 slide), NMV J17257 (male, 4.2 mm, with 1 slide), NMV J17258 (2 males, 3.0, 4.8 mm, 2 non-ovig. females, 3.9, 4.1 mm, 6 ovig. females, 4.6, 4.8, 5.0, 5.1, 5.2, 5.2 mm).

Diagnosis. Pleonite 5 convex dorsomedially, without carinae. Pleotelson flattened, with weakly raised lateral crests, with 3 pair of flattened longitudinal carinae, anteromedial pair broad. Pleonite 5 0.5 times as long as pleotelson. Dorsal surface of pleotelson with scales fused, covered with solitary scale spikes, without pits. Posterior margin of pleotelson with dorsal row of scale spikes; margin fringed with 4 stout setae between which are short unsheathed setae and scale spikes.

Antenna 1 with 4 flagellar articles; second article with about 11 aesthetascs, third article narrow. Flagellum of antenna 2 with 4 articles. Mandibular palp with 3 articles. Mandibular incisors without rasp and file. Lacinia mobilis of right mandible unbranched, apically serrated. Epipod of maxilliped strap-like, 4 times as long as wide, reaching articulation of palp articles 1 and 2; epipod with simple true setae.

Secondary unguis of pereopod 1 bifid. Ventral comb seta present on merus of pereopod 7 and carpus of pereopods 6, 7 and sometimes 5. Uropod peduncle with short lateral spike setae, without prominent tubercles; endopod 0.65 times as long as peduncle.

Pleopod 2 with plumose setae up to 0.8 times length of exopod. Appendix masculina long, reaching beyond endopod tip, articulating proximal to midlength of endopod. Endopod of pleopod 5 anterior to exopod, oval, 0.8 times as long as endopod of pleopod 2; peduncle of pleopod 5 with simple seta laterally.

Additional characters. Body length up to 5.2 mm. Colour in alcohol light pink for fresh material, becoming pale yellow upon prolonged storage. Article 2 of mandibular palp with more than 1 simple seta.

Etymology. From the Latin for carver (of holdfasts).

Distribution. Heard Island, Southern Ocean. Lower eulittoral.

Substrates. Durvillaea antarctica holdfasts.

Remarks. This species is similar to *L. stephenseni* and *L. antarctica*. However, *L. stephenseni* lacks carinae (other than lateral crests) and puncta on the pleotelson, whereas *L. carptora* has six flattened but distinct longitudinal carinae. Also, the ventral branch of the secondary unguis of pereopod 1 on *L. stephenseni* is greatly reduced (see figures by Menzies, 1957; Wolff, 1990; Cookson, 1991), while for *L. carptora* this ventral branch is much larger, and usually of similar proportion to that found in *L. antarctica*. The smallest ventral branch seen in the material examined is illustrated (Fig. 2e). *L. carptora* has four large stout setae on the posterior margin of the pleotelson, whereas *L. stephenseni* has many positioned around the entire hind perimeter of the pleotelson. Furthermore, *L. stephenseni* grows up to 9.8 mm long, while the longest *L. carptora* specimen found so far is 5.2 mm. The appearance of the lacinia mobilis of the right mandible may not be a reliable difference between the two species. It is simple in *L. carptora*, while in *L. stephenseni* it may be simple (Menzies, 1957; Wolff, 1990) or bifid (Cookson, 1991).

L. carptora differs from *L. antarctica* mainly in the sculpturing found on pleonite 5 and the pleotelson. *L. carptora* lacks a transverse carina on pleonite 5. On the pleotelson of *L. carptora*, the dorsomedial carinae are flatter and broader than for *L. antarctica*, and anteromedial puncta absent. Both *L. carptora* and *L. stephenseni* differ from *L. antarctica* in that they have less defined and raised lateral crests on the pleotelson, the dorsal surface between the lateral crests on the pleotelson is flatter, and article 3 of antenna 1 is more narrow. *L. carptora* can reach 5.2 mm, while the largest *L. antarctica* specimen found is 4.7 mm (Cookson, 1991).

In the key to the species of *Limnoria* (Cookson, 1991), *L. carptora* should be inserted between *L. antarctica* and *L. stephenseni* at step 35:

— Pleotelson with carinae, pleonite 5 without carinae dorsomedially. Secondary unguis of pereopod 1 bifid. Posterior margin of pleotelson with 4 stout setae. Substrate algae ..... *L. carptora*

The distribution of *L. carptora* and *L. antarctica* may overlap, as *L. antarctica* has been found at Kerguelen Island (Menzies, 1957), which is near Heard Island. However, *L. stephenseni* has not been found in the waters off either island. Its distribution is the Auckland Islands, Macquarie

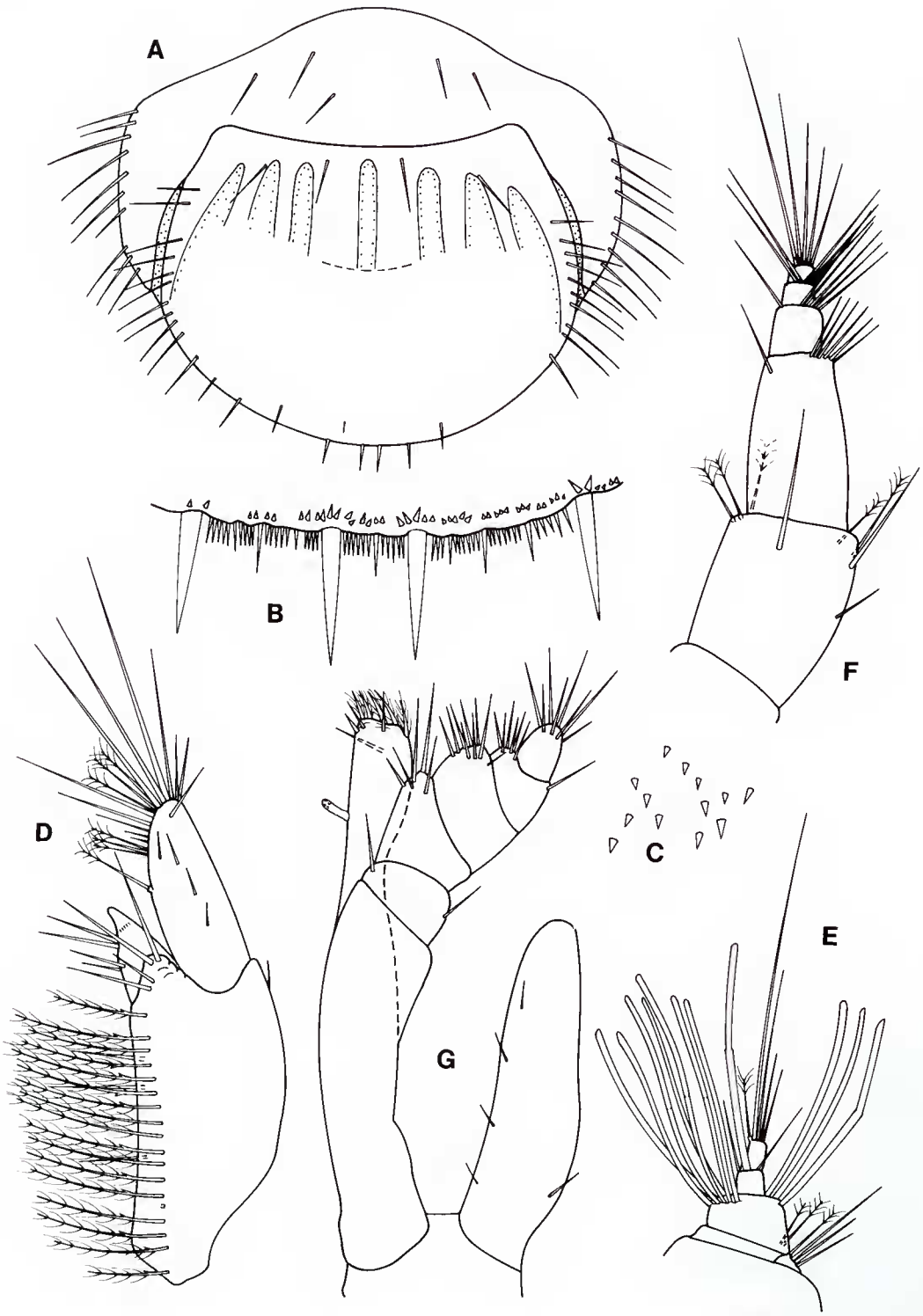

Figure 1. *Limnoria carptora* sp. nov. A-F, male, NMV J17255, holotype: A, pleonite 5 and pleotelson, dorsal view; B, posterior margin of pleotelson; C, dorsal surface of pleotelson; D, uropod, ventral view; E, flagellum of antenna 1; F, peduncle article 5 and flagellum of antenna 2. G, male, NMV J17257, paratype, maxilliped.

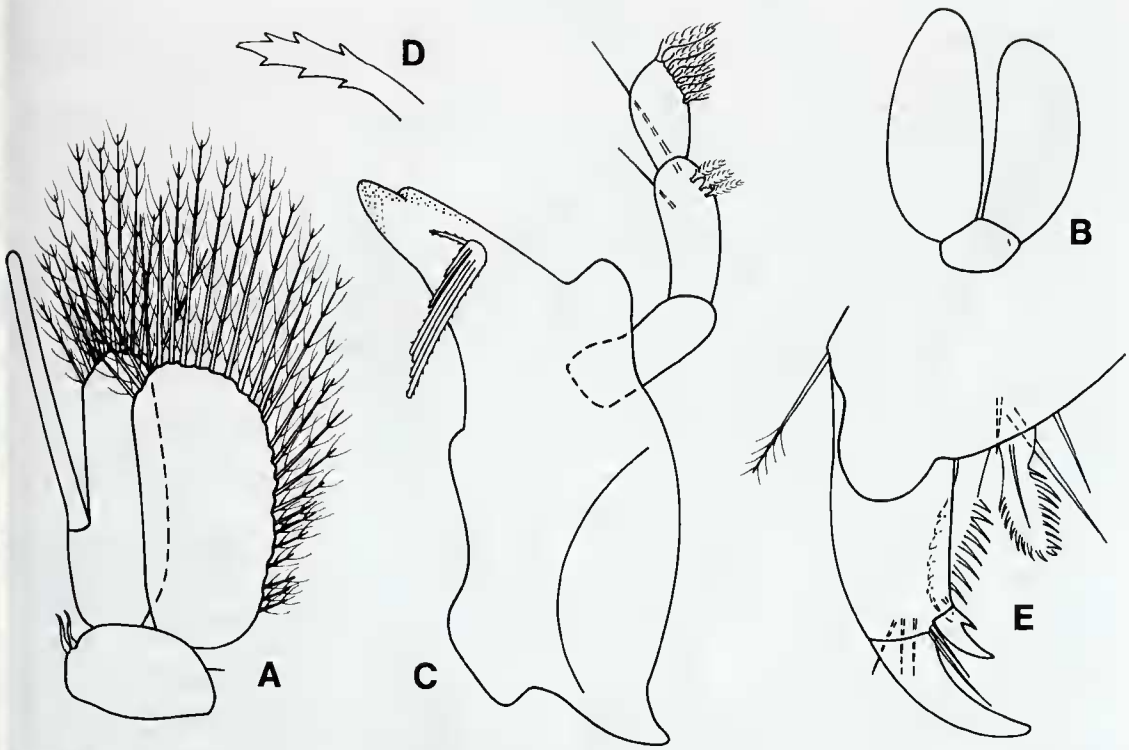

Figure 2. *Limnoria carptora* sp. nov. A-D, male, NMV J17255, holotype: A, pleopod 2; B, pleopod 5; C, right mandible; D, lacinia mobilis of right mandible. E, female, NMV J17256, paratype, distal articles of pereopod 1, lateral view.

Island and Marion Island (Wolff, 1990; Cookson, 1991). *L. stephenseni* and *L. carptora* have been collected from *Durvillaea* (Wolff, 1990; Cookson, 1991), and the former from *Macrocystis* as well (Hale, 1937). *L. antarctica* has been collected only from or near *Macrocystis* (Cookson, 1991).

Limnoria foveolata Menzies

Figure 3

Limnoria (Limnoria) foveolata Menzies, 1957: 175, fig 33.

Limnoria foveolata. — Cookson, 1991: 142. — Cookson, 1990: 2.

Material examined. Holotype, Kai Islands (6°5′S, 105°42′E), 52 m, Sigsbee trawl, sand, shells, Danish Expedition, 4 Aug 1922, ZMUC (non-ovig. female, with 2 slides).

Diagnosis (female). Pleonite 5 dorsomedially with 2 subparallel longitudinal weak carinae converging slightly posteriorly. Pleotelson with 1 pair of anteromedial puncta, with carinae posteriorly, with pair of weak anterolateral carinae. Pleonite 5 0.6 times as long as pleotelson. Dorsal surface of pleotelson with scales fused, covered with many solitary scale spikes. Lateral crests and posterior margin of pleotelson without dorsal row of tubercles; posterior margin fringed with 4 large stout setae between which are scale spikes and short-sheathed setae.

Antenna 1 with 4 flagellar articles; second article with 9 aesthetascs arising from 2 tufts. Flagellum of antenna 2 with 5 articles. Mandibular palp with 3 articles. Mandibular incisors with rasp and file. Lacinia mobilis of right mandible with several teeth at apex. Epipod of maxilliped subtriangular, about 3.3 times as long as wide, just short of palp articulation; epipod with true setae.

Secondary unguis of pereopod 1 bifid. Ventral comb seta present on merus of pereopod 7 and carpus of pereopods 2–7. Uropod peduncle without tubercles; endopod 0.9 times as long as peduncle.

Pleopod 2 with plumose setae up to 0.7 times length of exopod. Appendix masculina unknown. Endopod of pleopod 5 anterior to exopod, oval, 0.75 times as long as endopod of pleopod 2.

Additional characters. Body length 2.2 mm. Colour in alcohol pale yellow.

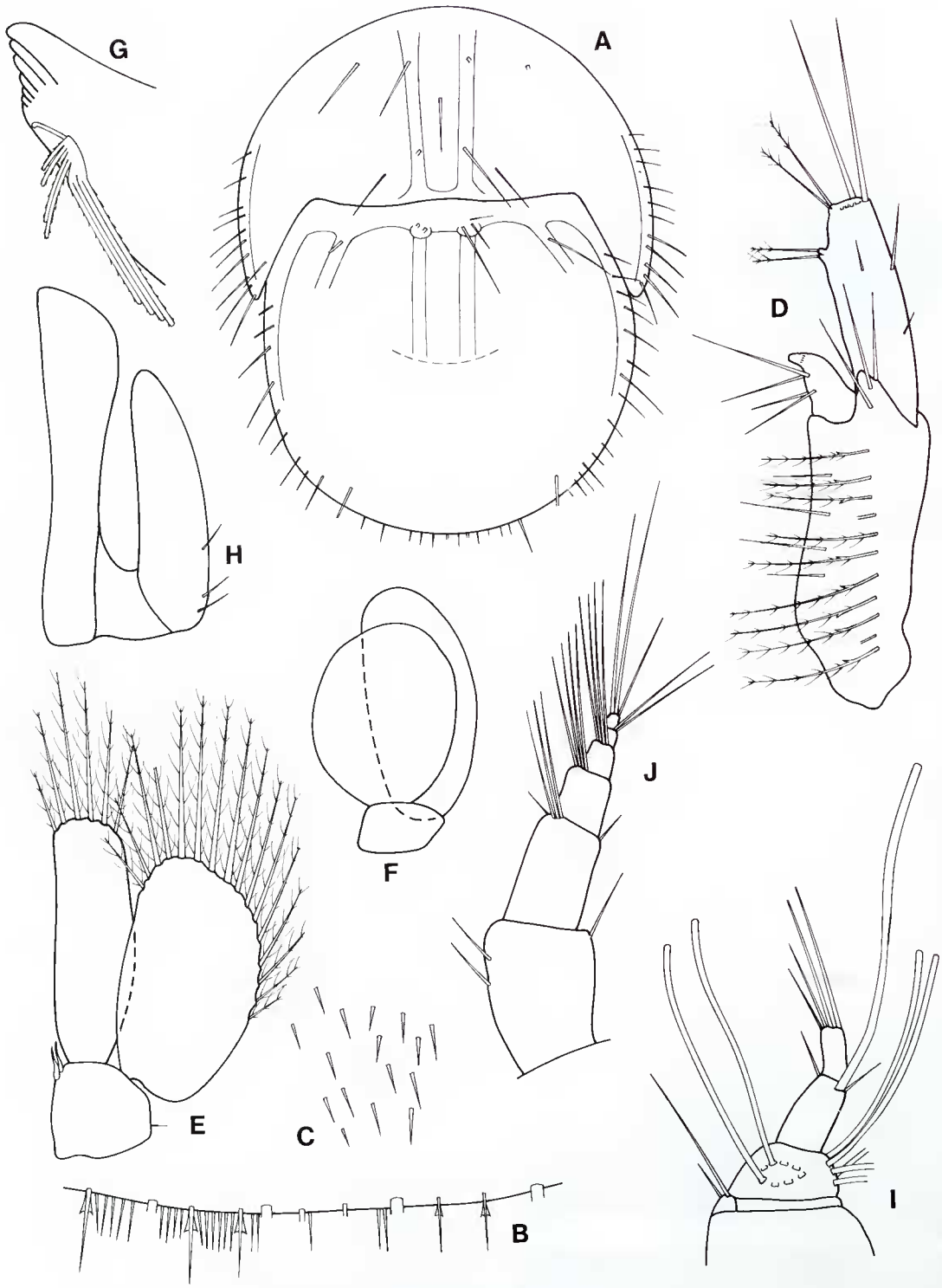

Figure 3. *Limnoria foveolata* Menzies. A-J, female, ZMUC, holotype: A, pleonite 5 and pleotelson, dorsal view; B, posterior margin of pleotelson, stout setae broken; C, dorsal surfaee of pleotelson; D, uropod, ventral view; E, pleopod 2; F, pleopod 5; G, distal portion of right mandible; H, epipod and basis of endopod of maxilliped; I, flagellum of antenna 1; J, pedunele artiele 5 and flagellum of antenna 2.

Distribution record. Known only from near the Kai Islands, Indonesia. 52 m depth.

Substrates. Unknown. The presence of rasp and file incisors on the mandibles suggests that this species is a wood or seagrass borer.

Remarks. Only the female holotype of *L. foveolata* is known, looking similar to female *L. indica* and *L. saseboensis* specimens. The differences that separate *L. foveolata* from these species remains unconvincing. Unfortunately, no male specimens of *L. foveolata* are known, which within this group of species is the sex that appears to offer most distinctive features. The pitted structure on the fifth pleonite and pleotelson must have been clearer when Menzies (1957) named this species for its foveolate appearance. However, when I examined the holotype the pitting could not be seen with reflected light at 80 times magnification, and was only slight at 800 times magnification using transmitted light. Perhaps some change in prominence of the pitting can occur upon storage. Such change was noted for the puncta of *Limnoria echidna* Cookson, although for this species the sculpturing became clearer upon storage (Cookson, 1991). I have not noticed dramatic loss in clarity of pitting in other species. At 80× magnification, an absence of pitting is characteristic of *L. indica*, while pitting is often clearly visible in the typical *L. saseboensis* specimen.

Menzies (1957) noted that *L. foveolata* differed from *L. saseboensis* in the lack of marginal tubercles on the pleotelson, and longer maxillipedal epipod. However, the latter character is variable, as some specimens of *L. saseboensis* have an epipod as long as that found in *L. foveolata*. The feature that distinguishes *L. foveolata* most easily from *L. saseboensis* and *L. indica*, is the lack of tubercles on the lateral crests of the pleotelson. *L. foveolata* also lacks tubercles on the posterior margin of the pleotelson, but this condition can be found in some specimens of both *L. saseboensis* and *L. indica* also. *L. foveolata* has a weak pair of anterolateral carinae on the pleotelson, which is normally absent in *L. indica* but present in *L. saseboensis*. However, the difference again is not impressive.

L. foveolata may become synonymised with either *L. saseboensis* or *L. indica* on the basis of future studies. The type locality lies within the distribution range of *L. indica*, not *L. saseboensis*.

Limnoria saseboensis Menzies

Figures 4, 5

Limnoria (Limnoria) saseboensis Menzies, 1957: 141, 144, fig 18. — Menzies, 1959: 22.

Limnoria saseboensis. — Kühne, 1976: 546–547, fig 5.-Jones et al., 1976: 134. — Kensley and Schotte, 1989: 198, fig 87D. — Cookson, 1991: 143 155. — Cookson, 1990: 4. — Cookson et al., 1991: 45.

Limnoria indica. — Cookson, 1987: 85–89, figs 1–8 (Goat Island material). — Cookson and Barnacle, 1987a: 143. — Cookson and Barnacle, 1987b: 287–293 (Goat Island material).

Material examined. Paratypes, Japan, Sasebo, W.F. Clapp, 22 Aug 1949 and 24 Jan 1950, USNM 91749 (5 males, 1 female; non-ovig female, 3.5 mm, with 1 slide: specimens in poor condition).

Japan, Sasebo (33°7′26″N, 129°44′16″E), 10 m, wood test panel submerged 6 Jul 1966–7 Dec 1966, BAM (5 females 2.5–3.6 mm, male 2.9 mm), Koniya, 1968, BAM (male 2.9 mm, female 3.0 mm),

NSW, Sydney, pine bait blocks, R.D. Turner and J.V. Marshall: Watsons Bay, 26 Nov 1971, AM P35378 (5), Watsons Bay, 4 Aug 1971, AM P37046, Cammeray, 10 Feb 1972, AM P35384 (1 male, 2 females up to 3.9 mm), Cabarita, 30 Jun 1971, AM P38269 (1), AM P37044 (2), Goat Island, 27 May 1970, AM P35389 (33), Goat Island, 1971, AM P35390 (24), Goat Island, 4 Feb 1972, AM P37042 (3), Goat Island, 0.5–1 m, *E. pilularis* timber, J. Beesley, 15 Sep 1975, NMV J37438 (2), various test timbers, L.J. Cookson and J.E. Barnacle, 1 Mar 1985, NMV J15258 (8), NMV J15263 (21), NMV J15257 (20), NMV J15259 (16), NMV J15260 (male, 3.1 mm, with 1 slide), NMV J15268 (3), NMV J15274 (20), NMV J15276 (9), L.J. Cookson, 18 Mar 1983, NMV J15264 (11) NMV J15265 (20) NMV J15266 (14), Coffs Harbour, Police Jetty Marina, *P. radiata* block placed 14 Jan 1988, R. Livesay and L.J. Cookson, 4 Jul 1988, NMV J15251 (5).

WA, Geraldton, wharf piles, R.D. Turner and J.V. Marshall, 7 Nov 1970, AM P37045 (2), CCA-treated jarrah piles pulled up on beach for several months, J.E. Barnacle, 1 May 1989, NMV J37443 (34), NMV J37442 (male, 3.7 mm), NMV J37444 (male 3.3 mm, with 1 side), NMV J37445 (male, 3.0 mm, with 1 slide), NMV J37446 (female, 3.4 mm, with 1 slide), NMV J37447 (intersex, 3.7 mm, with 1 slide), Geraldton, Fishing Boat Harbour, 1 m below low tide, jarrah piles, J. Boys, 5 May 1989, NMV J37440 (17), 28 Sep 1989, NMV J37439 (70), Roebourne, pine bait block, R. Howlett, Nov 1960, NMV J14934 (male), Point Samson, jetty, CCA-treated eucalypt pile, J.E. Barnacle, 15 Sep 1985, NMV J14962 (3) untreated eucalypt, NMV J14961 (3, with 1 slide), jarrah piles washed onto beach, J.E. Barnacle, 23 Apr 1989, NMV J37441 (8).

Qld, Wreck Reef, off Gladstone, (22°11′S, 155°15′E), 12 m, in *Casuarina* from 'Cato' shipwreck, W. Delaney, 18 May 1988, NMV J15210 (4 pleotelsons). Urangan Boat Harbour, Maryborough, low tide, turpentine pile, J.E. Barnacle, 10 Feb 1986, NMV J14995 (3), NMV J14996 (13).

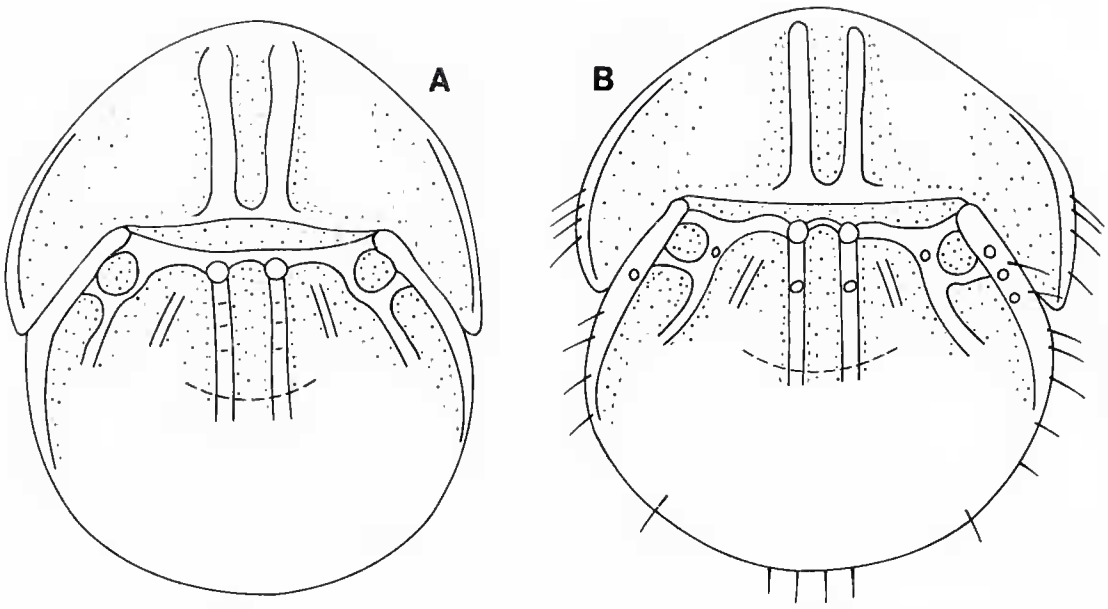

Figure 4. *Limnoria saseboensis* Menzies. A, female from Sasebo, USNM 91749, paratype, pleonite 5 and pleotelson, dorsal view. B, male from Geraldton, NMV J37442, pleonite 5 and pleotelson.

Diagnosis (male). Pleonite 5 dorsomedially with 2 subparallel longitudinal carinae which may converge slightly posteriorly. Pleotelson with 1 or 2 pairs of anteromedial puncta, if two pairs, then one is directly behind other at a distance equal to or longer than distance between anterior puncta, with carinae behind posterior pair of puncta, with an anterolateral pair of puncta or long setae each anterior to short lateral carina. Pleonite 5 0.5 times as long as pleotelson. Dorsal surface of pleotelson with scales fused, covered with many solitary scale spikes, sometimes strongly pitted anteriorly. Dorsal row of tubercles extend from lateral crests to posterior margin of pleotelson; posterior margin fringed with 4 large stout setae between which are scale spikes and short-sheathed setae.

Antenna 1 with 4 flagellar articles; second article with about 15 aesthetascs arising from 2 tufts. Flagellum of antenna 2 with 5 articles. Mandibular palp with 3 articles. Mandibular incisors with rasp and file. Lacinia mobilis of right mandible straight, apex with several teeth. Epipod of maxilliped subtriangular, about 3 times as long as wide, not reaching palp articulation; epipod with true setae.

Secondary unguis of pereopod 1 bifid. Ventral comb seta present on merus of pereopod 7 and carpus of pereopods 2–7. Uropod peduncle laterally with short simple setae; with small tubercles between plumose setae; endopod 0.85 times as long as peduncle.

Pleopod 2 with plumose setae up to 0.5 times length of exopod. Appendix masculina reaching apex of endopod of pleopod 2, articulating just proximal to midlength of endopod. Endopod of pleopod 5 anterior to exopod, broadly oval to circular, 0.7 times as long as endopod of pleopod 2; peduncle of pleopod 5 with simple seta laterally.

Additional characters. With sexual dimorphism of pleotelson sculpturing; female with pair of anteromedial puncta followed posteriorly by long carinae, pleotelson without other puncta. Body length up to 4.1 mm. Colour in alcohol pale yellow.

Distribution. Sasebo, Japan; Florida (Menzies, 1957); Japan (Kühne, 1976). Eastern Australia from Sydney to Maryborough. Western Australia from Geraldton to Point Samson near Roebourne (current study). Depth range 0–12 m.

Substrates. From a causeway, presumably in wood (Menzies, 1957). *P. radiata* and various eucalypt timbers which were either untreated or preservative treated, *Syncarpia glomulifera* (turpentine), *Casuarina* (current study).

Remarks. For some time I wrongly identified certain populations of this species as the very similar *L. indica* (Cookson, 1987, Cookson and Barnacle, 1987b). However, all references to *L. indica* and *L. saseboensis* in Cookson (1991) are correct.

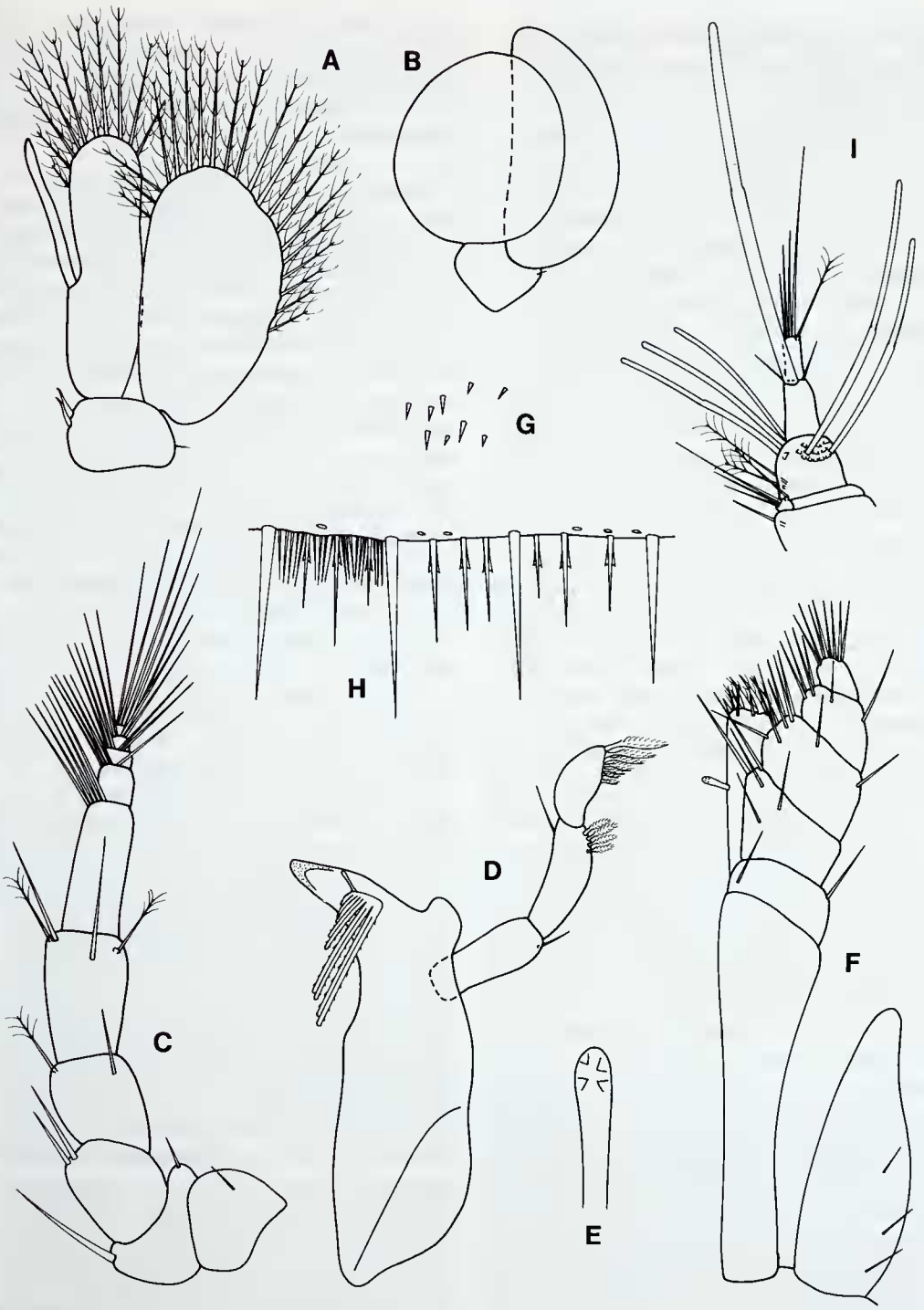

Figure 5. *Limnoria saseboensis* Menzies. A-B, male from Sasebo, USNM 91749, paratype: A, pleopod 2, *in situ*; B, pleopod 5, *in situ*. C-F, female from Sasebo, USNM 91749, paratype: C, antenna 2; D, right mandible; E, lacinia mobilis of right mandible; F, maxilliped. G-H, male from Geraldton, NMV J37442: G, dorsal surface of pleotelson; H, posterior margin of pleotelson. I, male from Point Samson, NMV J14961, flagellum of antenna 1.

Often, there is no difference between *L. saseboensis* and *L. indica* in shape or length of the maxillipedal epipod (Kühne, 1976; current study), although this character was used by Menzies (1957). Another character that cannot be relied upon is the slight posterior convergence of the longitudinal parallel carinae found dorsally on pleonite 5 (Kühne, 1976; current study figs 4a and 4b). The degree of pitting found on pleonite 5 and the pleotelson, as exemplified in Fig. 18D given by Menzies (1957), also varies. This pitting was well developed in the paratypes of *L. saseboensis*. However, many specimens from Australia lack the large carinated pits found on the typical *L. saseboensis* specimen, so resemble *L. indica* where carinated pits are not noticeable at low magnification (80x). These pits are noticeable on *L. indica* at higher magnification (Kensley and Schotte, 1987). Menzies (1957) did not give the number of puncta found on the two parallel carinae on the dorsal surface of the pleotelson: "carinae tuberculate anteriorly and less so posteriorly". The male however has either two or four puncta, and the female two puncta. Few specimens are without puncta. Also, some male specimens from Australia and Japan have an anterolateral pair of puncta on the pleotelson, similar to that sometimes found on *L. indica* males (Kühne, 1976; current study). These were not to be found in the type material, although for some, a large seta at the equivalent position was noted. Therefore, the sexual dimorphism found in *L. indica* can also occur in some specimens of *L. saseboensis*. To further complicate the matter, the lacinia mobilis on the right mandible of *L. saseboensis* was said to have two medially curved teeth at the apex (Menzies, 1957). However, the number of teeth found can be greater than this (Fig. 5e; Cookson, 1987, Figs. 6–8), and so is similar to the lacinia mobilis found on *L. indica*.

The population of *L. saseboensis* on the west coast of Australia often differs from the population on the east coast. While some males from both coasts have the pair of anterolateral puncta on the pleotelson, most males from eastern Australia have two pairs of anteromedial puncta, and most males in Geraldton have just one pair of anteromedial puncta. However, this is not a constant difference that could be used to separate the two populations as species. One male in the Geraldton material (Fig. 4b) had all six puncta. Also, the single male from Roebourne (NMV J14934) had six prominent puncta (Roebourne is an inland location, so the point of collection was probably Point Samson). The six puncta (four anteromedial, two anterolateral) often found in male *L. saseboensis* from eastern Australia is clearly shown in the Fig. 2 provided by Cookson (1987). In this regard, *L. saseboensis* males from eastern Australia can look very similar to *L. indica* males.

The most reliable difference to be found between male *L. indica* and male *L. saseboensis* specimens is that *L. indica* always has two pair of anteromedial puncta, while *L. saseboensis* may be without puncta or have just one pair. If *L. saseboensis* has two pairs of puncta, then the two puncta born on the same longitudinal carina will be further apart or equal in distance to each other, than they are with their paired partner. In other words, the four puncta are longitudinally more separated than laterally separated. For *L. indica*, the two pair of puncta are always wider apart than longer apart. Sometimes, the posterior pair are especially wide, as was drawn in the original description by Becker and Kampf (1958), and shown in SEM photographs by Kensley and Schotte (1987). Also, male *L. saseboensis* have carinae posterior to the hind pair of anteromedial puncta, while *L. indica* males do not. The key given by Cookson (1991) correctly separates male *L. saseboensis* and *L. indica*, based upon this character of carina presence or absence behind the pleotelson puncta.

Other characters if present and clear, can assist in identification. Lateral carinae (those medial of lateral crests) are usually present in both sexes of *L. saseboensis*. Such lateral carinae are absent, or very slightly developed in *L. indica*. The surface pitting of pleonite 5 and the pleotelson can also be useful if developed. In Australia, pitting was rare in the west coast specimens, but more common in those from eastern Australia, where the level of pitting was also variable between individuals from the same population. Another related character, found in most but not all specimens of *L. saseboensis*, was the pair of large circular carinae adjoining the anterior end of the lateral crests. This circular carina is constructed from several portions: the anterior portion of the lateral crest, the anterolateral carina and puncta, and two bridging carinae (Figs. 4a, b). *L. indica* has the lateral crest portion, and often the anterolateral puncta, but the remaining components are essentially absent. The endopod of pleopod 5, another variable character, tends to be rounder in *L. saseboensis* than *L. indica*.

It can at times be difficult or impossible, based upon known characters, to separate female *L. indica* and *L. saseboensis*. This is especially true

if pitting and lateral carinae on the pleotelson are absent or ill defined. One further notable difference is that *L. saseboensis* is often larger. The longest *L. indica* specimen known is 3.3 mm, whereas the longest *L. saseboensis* specimen is 4.1 mm.

In Australia, *L. saseboensis* has a warm temperate distribution, while *L. indica* is tropical and subtropical in range. Overlap of the two species has not been observed. In eastern Australia *L. saseboensis* extends from Sydney to as far north as Maryborough, while *L. indica* can be found from Gladstone to Papua New Guinea. In Western Australia *L. indica* has not been found. This absence might explain why *L. saseboensis* can be found further north than on the east coast, from Geraldton to Point Samson. *L. saseboensis* and *L. indica* appear to have similar substrate preferences, in that, within their distribution range on the east coast, they are the limnoriid species most likely to be found on untreated turpentine timbers (Cookson, 1987; further unpublished data).

Limnoria simulata Menzies

Figures 6, 7

Limnoria (Limnoria) simulata Menzies, 1957: 144, fig 19. — Menzies, 1959: 20.

Limnoria simulata. — Carvacho, 1977: 17–18, figs 5 g-i (possibly). — Kensley and Schotte, 1987: 222. — Müller, 1988: 397–403, figs 1–23 (Colombian material). — Kensley and Schotte, 1989: 198. — Cookson, 1991: 143, 192–193. — Cookson, 1990: 6.

Not *Limnoria simulata.* — Müller, 1988: 398 (Indian material). — McKoy-Hill, 1964: 46.

Material examined. Holotype, West Indies, Virgin Islands, 16 Feb 1914, ZMUC (male, 3.0 mm, with 1 slide). Paratype, type locality, ZMUC (male).

USA, Florida, north of North Key, Tarpon Springs, 1 m, found on *Thalassia* on mud flat, water temperature 13.3°C , salinity 23.6, Phillips, Greeley, Mann, 19 Dec 1958, USNM 103005 (leaf with burrow, 2 females missing cephalon, male 2.5 mm, with 1 slide, ident. by R.J. Menzies).

Colombia, Bahia de Nenguangue, near Santa Marta, 0.5 m, *Thalassia*, H.-G. Müller, 17 Jan 1986, ZMUC (12 males, 2 females), 0–1 m, 5 Aug 1985, ZMUC (6 males, 4 females, 1 juvenile)

Diagnosis (male). Pleonite 5 dorsomedially with a faint longitudinal sulcus. Pleotelson with 1 or 2 pairs of anteromedial puncta, if two pairs, then puncta wider apart than longitudinally apart, without carinae; with an anterolateral pair of puncta or setae. Pleonite 5 0.5–0.6 times as long as pleotelson. Dorsal surface of pleotelson with scales partially fused, bordered posteriorly with several short scale spikes, sometimes slightly pitted anteriorly. Dorsal row of tubercles on lateral crests of pleotelson, some bearing several short scale spikes; posterior margin fringed with 4–6 large stout setae between which are scale spikes and short-sheathed setae, lacking posterior row of tubercles, sometimes with irregular row of short scale spikes in groups of 2–5.

Antenna 1 with 4 flagellar articles; second article with about 6–11 aesthetascs. Flagellum of antenna 2 with 5, sometimes 4 articles. Mandibular palp with 3 articles. Mandibular incisors with rasp and file, rasp confined to distal half of incisor. Lacinia mobilis of right mandible straight, apex with several long or short teeth. Epipod of maxilliped subtriangular, about 3 times as long as wide, reaching or just short of palp articulation; epipod with true setae.

Secondary unguis of pereopod 1 bifid. Ventral comb seta present or absent on merus of pereopod 7, present on carpus of pereopods 2–7. Uropod peduncle laterally with or without small tubercles between plumose setae; endopod 0.75–1 times as long as peduncle.

Pleopod 2 with plumose setae up to same length of exopod. Appendix masculina reaching beyond apex of endopod of pleopod 2, articulating near midlength of endopod. Endopod of pleopod 5 anterior to exopod, oval, 0.8 times as long as endopod of pleopod 2.

Additional characters. Sculpturing on pleotelson often sexually dimorphic, as female has just one anteromedial pair of puncta, followed posteriorly by weak parallel carinae; female without anterolateral puncta. Body length up to 3.2 mm (Müller, 1988). Colour in alcohol pale yellow.

Distribution. Virgin Islands, West Indies (Menzies, 1957); Caribbean Sea of north Colombia (Müller, 1988); Tarpon Springs, Florida (current study). Depth: 0–4 m (Müller, 1988).

Substrates. Washed from the seagrass *Thalassia testudinum* (Müller, 1988); leaves of the seagrass *Thalassia* (current study).

Remarks. Some variations in the specimens were noted. The ventral comb seta on the merus of pereopod 7 was present in the specimens from Tarpon Springs, and in some specimens from Colombia, but absent in both types. The flagellum of antenna 2 was drawn to have four articles by Menzies (1957). However, this was difficult to confirm from the slide that he had prepared, as the tip was hidden by setae and debris. The male paratype examined *in situ* had five articles,

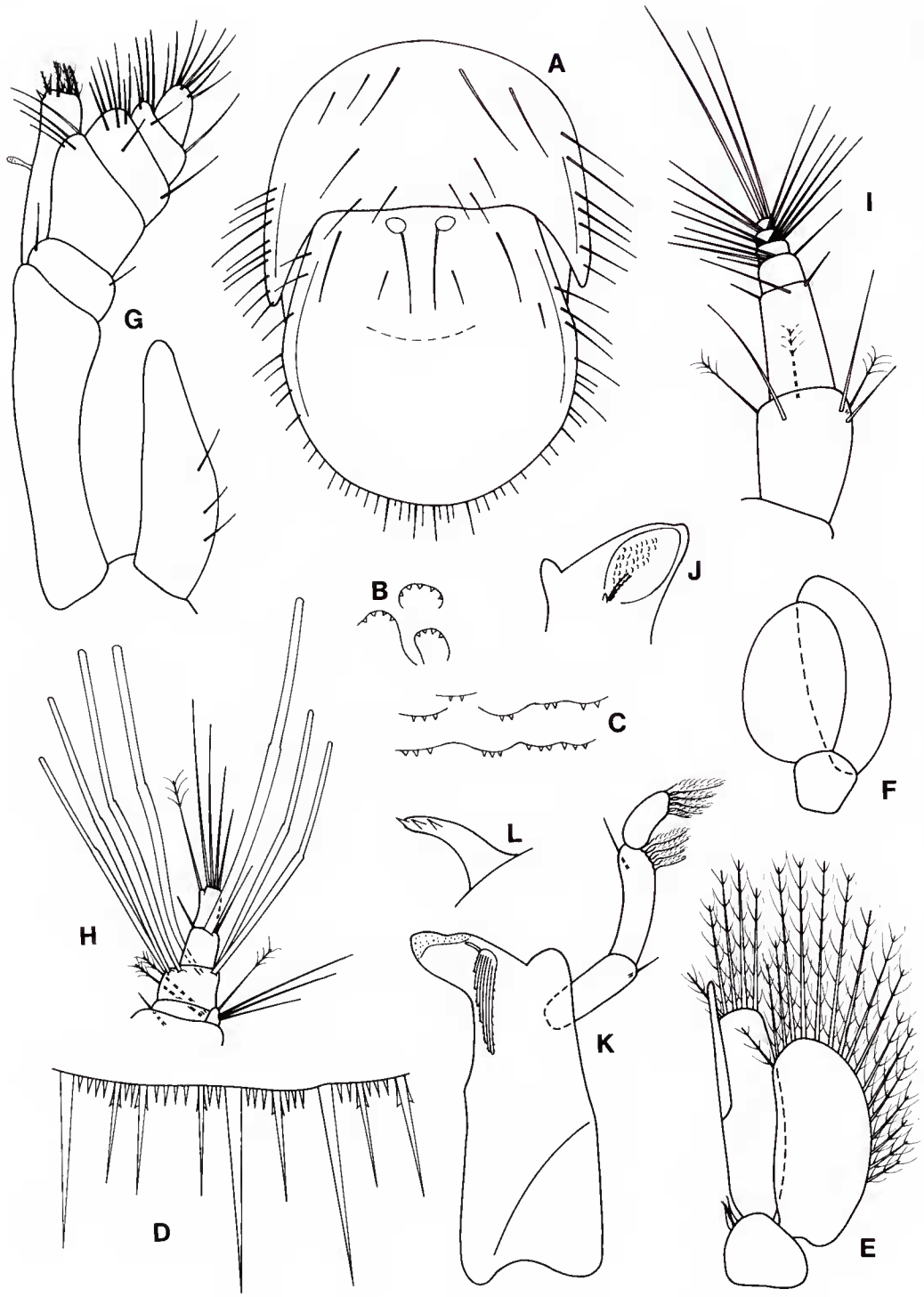

Figure 6. *Limnoria simulata* Menzies. A-L, male, USNM 103005: A, pleonite 5 and pleotelson, dorsal view; B, anterodorsal surface of pleotelson; C, posterodorsal surface of pleotelson; D, posterior margin of pleotelson; E, pleopod 2; F, pleopod 5; G, maxilliped; H, flagellum of antenna 1; I, pedunele article 5 and flagellum of antenna 2; J, incisor of left mandible; K, right mandible; L, laeinia mobilis of right mandible.

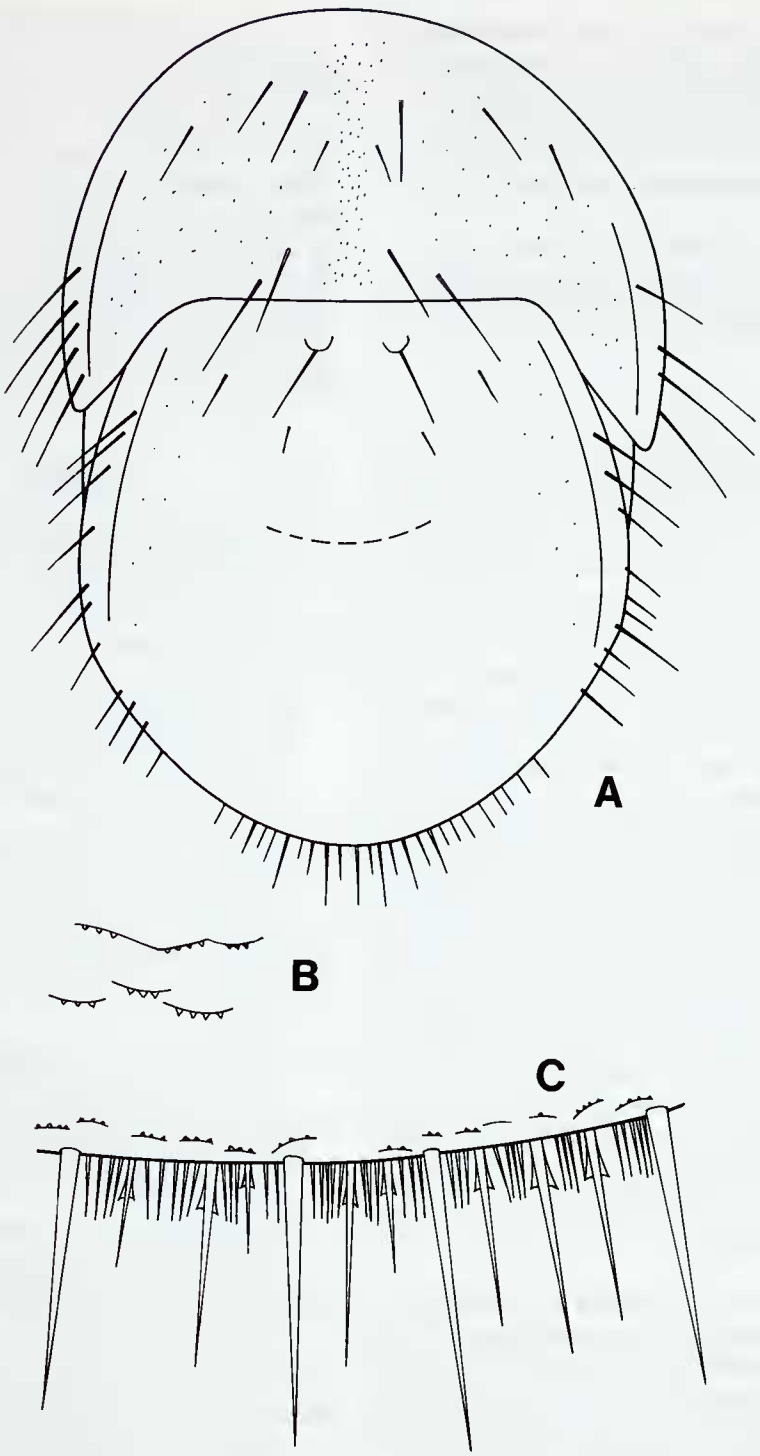

Figure 7. *Limnoria simulata* Menzies. A-C, male, ZMUC, paratype: A, pleonite 5 and pleotelson, dorsal view; B, posterodorsal surface of pleotelson; C, posterior margin of pleotelson.

although the last was very small. Müller (1988) also noted five articles in his specimens. The posterior margin of the pleotelson bore six stout setae in both type specimens, and in both females from Tarpon Springs, whereas the male from Tarpon Springs had four stout setae.

L. simulata, *L. indica*, *L. saseboensis*, and *L. hicksi* Schotte, are all known to share, for some specimens at least, the pattern on the pleotelson of two anteromedial and one anterolateral pairs of puncta.

L. simulata is most similar to *L. indica*, and Müller (1988) synonymised *L. indica* with *L. simulata*. However, I propose that the two should remain separate species. *L. simulata* has carinae on pleonite 5 much less defined than for *L. indica*. In the specimens of *L. simulata* examined, there was a faint longitudinal sulcus on pleonite 5. What might have been carinae on either side of the sulcus, were so gradually merged with the general surface, that I would prefer not to call them carinae. Sulcus is the term used by Menzies (1957). *L. simulata* generally has longer and more numerous setae dorsally on pleonite 5 than *L. indica*. The anteromedial puncta on the pleotelson of *L. simulata* are much less defined than for *L. indica*. Often there is just one anteromedial pair of puncta on the pleotelson of *L. simulata*, not two as always occurs for *L. indica*. *L. simulata* lacks tubercles on the posterior margin of the pleotelson, while the majority of *L. indica* have these. Both species have tubercles on the lateral crests, though often less developed in *L. simulata* than *L. indica*. *L. simulata* often has six stout setae on the posterior margin of the pleotelson, while *L. indica* has just four. Both the plumose setae on pleopod 2, and the appendix masculina, are longer in *L. simulata* than *L. indica*. The rasp of the right mandible is much reduced compared to that found in *L. indica*.

Many of these differences are differences of gradation. However, the dorsal structure of the surface of the pleotelson is quite different. *L. indica* has large solitary scale spikes, whereas *L. simulata* has short teeth-like scale spikes arranged in rows as groups of mostly three to five. For *L. simulata*, some of these scale spikes can also be seen on the tubercles on the lateral crests. Another important ecological difference is that *L. simulata* is a seagrass borer, while *L. indica* has been found only in wood.

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